Claims

[c1] A computer assisted surgery system with enhanced graphic capabilities for insertion of guide pins into a body part, the system comprising:

an x-ray imaging device for generating at least one 2-D image of a body part;

means for displaying the at least one 2-D image of the body part;

a surgical instrument with a physical feature defining a real trajectory;

a localizing device for measuring the pose of the surgical instrument;

means for generating a graphic representation of the real trajectory;

means for determining the location of one or more virtual trajectories relative to the real trajectory; and

means for superimposing graphic representations of the real and virtual trajectories over the at least one 2-D image of the body part;

wherein the virtual trajectories may be used for assisting the surgeon in aligning the drill guide relative to the body part or guide pins and said virtual trajectories need not represent a real feature of the surgical instrument.

[c2] The computer assisted surgery system of claim 1 wherein the surgical instrument is a drill guide, the real trajectory represents the bore of the drill guide and the virtual trajectories represent future possible drill guide trajectories.

[c3] The computer assisted surgery system of claim 2 further comprising:

means for recording the pose of the drill guide at a signal from the surgeon; and

means for retaining graphic representations of the real and virtual trajectories superimposed on the 2-D image of the body part corresponding to the recorded pose;

wherein the retained virtual trajectories serve as guide lines for subsequent pin insertions.

[c4] A method for inserting multiple guide pins into a bone, the method comprising the steps of:

(a) generating at least one x-ray image of the bone and displaying said at least one x-ray image on a display means;

(b) positioning a drill guide in the vicinity of the bone, said drill guide comprising a bore portion that defines a real trajectory for drilling;

(c) generating a graphic representation of the real trajectory and one or more virtual trajectories, said virtual trajectories having fixed and known relationships to the real trajectory and representing possible positions for subsequent real trajectories;

(d) superimposing the representations of the real trajectory and virtual trajectories over the at least one x-ray image of the bone;

(e) repositioning the drill guide into a desired position relative to the bone; and

(f) inserting a guide pin into the bone;

wherein the surgeon positions the drill guide based on the alignment of the graphic representations of the real and virtual trajectories relative to the image of the bone.

[c5] The method of claim 4 wherein steps (a) to (f) are repeated for each guide pin to be inserted and for each guide pin inserted subsequent to the first guide pin the surgeon positions the drill guide based on the alignment of the graphic representations of the one or more virtual trajectories with images of one or more previously placed guide pins.

[c6] The method of claim 4 wherein the representation of the real trajectory is graphically distinguishable from the representations of the virtual trajectories.

[c7] The method of claim 4 wherein the insertion of the first guide pin further comprises the steps of:

(g) recording the pose of the drill guide at the time the guide pin was inserted;

(h) generating a second graphic representation of the real trajectory and one or more virtual trajectories; and

(i) retaining a superposition of the graphic representation of the real drilling trajectory and one or more virtual trajectories over the at least one

x-ray image of the bone at positions corresponding to the recorded pose; wherein the retained graphic representation of the real and virtual trajectories remains visible for subsequent guide pin insertions.

[c8] The method of claim 7 wherein steps (a) to (g) are performed for the first guide pin, and steps (a) to (f) are repeated for each subsequent guide pin to be inserted and the graphic representation of the drill guide for the subsequent steps comprises the real trajectory and the surgeon positions the drill guide based on the alignment of the real trajectory with a retained virtual trajectory from step (i).

[c9] A computer assisted surgery system for orienting an acetabular component during total hip replacement surgery comprising:

an imaging device for generating at least two 2-D images of a body part;

means for displaying the 2-D images of the body part;

means for specifying the locations of at least three pelvic landmarks on the 2-D images;

means for calculating a pelvic coordinate frame based on the at least three pelvic landmarks;

a positioning instrument attachable to the acetabular component, said positioning instrument's pose being measured by a localizing device; and

means for displaying the orientation of the acetabular component relative to the pelvic coordinate frame.

[c10] The computer assisted surgery system of claim 9 wherein the means for specifying the locations of the at least three pelvic landmarks comprises:

a probe having a real tip portion, said real tip portion defining a virtual tip portion correlating with a point in space located in a fixed and known relationship to the real tip portion, the position of said probe being measured by a localizing device;

means for generating a graphic representation of the virtual tip portion;

means for superimposing the graphic representation of the virtual tip portion over the 2-D images of the body part; and

means for signaling to the system;

wherein the surgeon uses the signaling means to indicate to the system that the graphic representation of the virtual tip is aligned over the image of a pelvic landmark in the 2-D images.

[c11] A method for orienting an acetabular component during a total hip replacement surgery comprising the steps:

(a) acquiring two roughly orthogonal x-ray images of at least three bony landmarks of a patient's pelvis;

(b) specifying the location of each of the three landmarks in the two x-ray images by positioning a cursor over the landmark in both images;

(c) calculating the 3-D position of each of the three landmarks from the specified cursor positions;

(d) defining a pelvic coordinate frame based on the calculated positions of the three landmarks;

(e) attaching the acetabular component to a positioning instrument;

(f) measuring the pose of the positioning instrument with a localizing device;

(g) calculating information regarding the orientation of the acetabular component relative to the pelvic coordinate frame; and

(h) displaying the calculated orientation information to the surgeon;

wherein the surgeon uses the information to place the acetabular component into a desired orientation.

[c12] The method of claim 11 wherein positioning the cursor is accomplished in step (b) by manipulating a mouse, trackball, joystick or other input device.

[c13] The method of claim 11 wherein the cursor is a graphic representation of a probe and positioning the cursor in step (b) comprises the steps of:

generating a graphic representation of the probe which indicates a virtual tip position at some known distance from the real tip of the probe;

measuring the position of the probe with a localizing device;

superimposing the graphic representation of the virtual tip on the two x-ray images; and

repositioning the probe in space such that the virtual tip coincides with

the bony landmark in both x-ray images.

[c14] The method of claim 11 wherein displaying information to the surgeon in step (g) further comprises the steps of:

generating a graphic representation of the positioning instrument and acetabular component; and

superimposing said graphic representation on one or more images of the patient's pelvis based on the measured pose of the positioning instrument;

wherein the surgeon is able to view and adjust the orientation of the acetabular component relative to imaged anatomy of the pelvis.

[c15] The method of claim 11 wherein displaying information to the surgeon in step (g) further comprises the steps of:

defining an axis of the acetabular component;

calculating the angular difference between the axis of the acetabular component and an axis of the pelvic coordinate frame; and

reporting the angular difference between the axes to the surgeon.

[c16] The method of claim 11 wherein the three bony landmarks comprise the left anterior superior iliac spine, the right anterior superior iliac spine, and the anterior portion of the pubic bone.

[c17] A computer assisted surgery system with enhanced graphic capabilities for noninvasively determining the location of a specific point within a body, the system comprising:

an x-ray imaging device for generating at least two 2-D images of a body part;

means for displaying the 2-D images of the body part;

a probe having a real tip portion, said real tip portion defining a virtual probe tip portion correlating with a point in space located in a fixed and known relationship to the real tip portion;

a localizing device for measuring the pose of the probe relative to the imaging device;

means for generating a graphic representation of the virtual tip portion;

and

means for superimposing a graphic representation of the virtual tip portion over the 2-D images of the body part;

wherein the three-dimensional location of a specific point within the body may be calculated from the pose of the probe when, in the at least two images, the representation of the virtual tip overlays the specific point within the body.